533 Rec'd PCT/PTO 10 SEP 2001

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371	ATTORNEY'S DOCKET NUMBER 20513/0572 U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 09/936168

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/FR00/00373	15 February 2000	9 March 1999

TITLE OF INVENTION

CATALYTIC REACTOR WITH ARRAY OF PLATES

APPLICANT(S) FOR DO/EO/US

LEVY, William, JOLY, Pierre, SABIN, Dominique, HUGUET, Régis, GRAILLE, Gilbert, BUSSONNET, Pierre, GILBERT-DESVALLONS, Eric

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. § 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the Annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter
16. ☒ Other items or information:

    Copy of the PCT Request; copy of PCT/IB/304; copy of the International Preliminary Examination Report; copy of the amendments made under PCT Article 34

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U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 09/936168	INTERNATIONAL APPLICATION NO. PCT/FR00/00373	ATTORNEY'S DOCKET NUMBER 20513/0572	
☒ The following fees are submitted:		CALCULATIONS	PTO USE ONLY

Basic National Fee (37 CFR 1.492(a)(1)-(5)):
Search Report has been prepared by the EPO or JPO..**$860.00**
International preliminary examination fee paid to USPTO (37 CFR 1.482) **$690.00**
No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2))..**$710.00**

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO..**$1,000.00**

International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4)..**$100.00**

				CALCULATIONS	PTO USE ONLY
ENTER APPROPRIATE BASIC FEE AMOUNT =				**$860.00**	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☒ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				**$130.00**	
Claims	Number Filed	Number Extra	Rate		
Total Claims	21 - 20 =	1	X $18.00	**$18.00**	
Independent Claims	1 - 3 =	0	X $80.00	**$0.00**	
Multiple dependent claim(s)(if applicable)			+ $270.00	**$0.00**	
TOTAL OF ABOVE CALCULATIONS =				**$1008.00**	
Reduction by 1/2 for filing by small entity, if applicable.				**$0.00**	
SUBTOTAL =				**$1,008.00**	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				**$0.00**	
TOTAL NATIONAL FEE =				**$1,008.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				**$0.00**	
TOTAL FEES ENCLOSED =				**$1,008.00**	
				Amount to be: refunded	$
				charged	$

a. ☒ A check in the amount of $1,008.00 to cover the above fees is enclosed.
b. ☐ Please charge my Deposit Account No. 22-0185 in the amount of $________ to cover the above fees. A duplicate copy of this sheet is enclosed.
c. ☒ The Director is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 22-0185. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b) must be filed and granted to restore the application to pending status

SEND ALL CORRESPONDENCE TO:
Connolly Bove Lodge & Hutz LLP
1990 M Street, N.W., Suite 800
Washington, DC 20036-3425

SIGNATURE 44,100
Morris Liss
NAME
24,510
REGISTRATION NUMBER

0936168 .090201

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	
William Levy et al.	
Serial No.: To be assigned	Art Unit: To be assigned
Filed: Herewith	Examiner: To be assigned
For: CATALYTIC REACTOR WITH ARRAY OF PLATES	Atty Docket: 20513/0572

PRELIMINARY AMENDMENT

Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to initial examination, please amend the above-captioned case as follows.

IN THE SPECIFICATION

Please amend the specification as shown on the attached sheets. Clean copies of the affected paragraphs are attached hereto.

IN THE CLAIMS

Kindly amend claims 5-16 and 18 to read as follows:

5. (Amended) The catalytic reactor as claimed in claim 1, wherein the channels of the first circuit and of the second circuit alternate with one another.

6. (Amended) The catalytic reactor as claimed in claim 1, wherein the plates of the bundle of plates form on the one hand, along the axis of the sealed chamber, a central well into which a first end of the channels of the first and of the second circuit respectively, emerge and, on the other hand, with said sealed chamber, an annular space into which a second end of the channels of the first and of the second circuit respectively, emerge.

7. (Amended) The catalytic reactor as claimed in claim 1, wherein the means for admitting the reaction fluid comprise an inlet nozzle passing through the sealed chamber and connected to the lower end of the central well of the bundle of plates so as to place the first end of the channels forming the first circuit for the circulation of this reaction fluid in communication with said inlet nozzle.

8. (Amended) The catalytic reactor as claimed in claim 1, wherein the means for removing the reaction fluid comprise an outlet nozzle emerging in said sealed chamber at the annular space and communicating with the second end of the channels forming the first circuit for the circulation of this reaction fluid.

9. (Amended) The catalytic reactor -as claimed in claim 1, wherein the means for admitting the heat-transfer fluid comprise a main nozzle passing through the sealed chamber and ducts each connecting said main nozzle and a vertical internal manifold spanning the entire height of the central well and covering a portion of the first ends of the channels that form the circuits.

10. (Amended) The catalytic reactor as claimed in claim 1, the means for removing the heat-transfer fluid comprise several ducts passing through the sealed chamber and each connected to a vertical external manifold spanning the entire height of the bundle of plates at the annular space and covering a portion of the second ends of the channels that form the second circuit.

11. (Amended) The catalytic reactor as claimed in claim 9, wherein the internal manifolds and the external manifolds are arranged in a star configuration.

12. (Amended) The catalytic reactor as claimed in claim 1, wherein the first ends of the channels forming the first circuit and situated between the internal manifolds are open and the first ends of said channels situated below the internal manifolds are blanked off, for example by a plate.

13. (Amended) The catalytic reactor as claimed in any claim 1, wherein the second ends of the channels forming the first circuit and situated between the external manifolds are open and the second ends of said channels situated below the manifolds are each blanked off, for example by a plate.

14. (Amended) The catalytic reactor as claimed in claim 1, wherein the first ends of the channels forming the second circuit and situated between the internal manifolds are blanked off, for example by a plate, and the first ends of said channels situated below the internal manifolds are open.

15 (Amended) The catalytic reactor as claimed in claim 1, wherein the second ends of the channels forming the second circuit and situated between the external manifolds are each blanked off for example by a plate and the second ends of said channels situated below the external manifolds are open.

16. (Amended) The catalytic reactor as claimed in claim 2, wherein the means for loading the catalyst into the channels of the first circuit are formed by an inlet duct passing through the upper part of the sealed chamber and connected to the open first ends of the channels forming the first circuit by a tubular sleeve arranged in the central well and spanning the entire height of said central well, said tubular sleeve allowing the reaction fluid to pass from the inlet nozzle as far as said open first ends.

18. (Amended) The catalytic reactor as claimed in claim 2, wherein the means for unloading the catalyst from the channels of the first circuit are formed by an outlet duct emerging at the lower part of the sealed chamber and connected to the open second ends of the channels forming the first circuit by a tubular sleeve arranged in the annular space and spanning from the upper edge of the bundle of plates as far as the lower part of said sealed chamber, said tubular sleeve allowing the reaction fluid to pass from said open second ends as far as the outlet nozzle.

REMARKS

The specification has been amended to incorporate the changes made under PCT Article 34. The claims have been amended to eliminate multiple dependency and to improve their format. None of these amendments is believed to involve any new matter. Accordingly, it is respectfully requested that the foregoing amendments be entered, that the application as so amended receive an examination on the merits, and that the claims as now presented receive an early allowance.

Respectfully submitted,

44,100

Morris Liss, Reg. No. 24,510
Connolly Bove Lodge & Hutz LLP
1990 M Street, N.W., Suite 800
Washington, D.C. 20036-3425
Telephone: 202-331-7111

Date: 9/10/01

AMENDMENTS TO THE SPECIFICATION

Page 1, paragraph 4:

The reaction fluid flows through these tubes inside which the chemical reaction takes place, and the heat-transfer fluid flows around the outside of the tubes, between these and the interior wall of the chamber.

Page 1, paragraph 6:

The specific problem is that the pressure drop in the catalyzer imposes a maximum length on the tubes and therefore dictates that there be a great many of the tubes.

On page 2, line 5, insert the following new paragraph:

U.S. Patent No. 4,340,501 discloses a catalytic reactor formed of a cylindrical chamber containing plate elements spaced apart and which determine a zig-zag path for the circulation of fluid.

On page 3, between paragraphs 1 and 2, insert the following paragraph:

Finally, an additional drawback of corrugated plates is the limited access they offer to the interior of the bundle of plates for inspecting these plates during shut-down of the catalytic reactor.

AMENDMENTS TO THE CLAIMS

5. (Amended) The catalytic reactor as claimed in claim 1 [or 2], [characterized in that] wherein the channels [(20; 30)] of the first circuit and of the second circuit alternate with one another.

6. (Amended) The catalytic reactor as claimed in [any one of the preceding claims] claim 1, [characterized in that] wherein the plates [(11)] of the bundle of plates [(10)] form on the one hand, along the axis of the sealed chamber [(1)], a central well [(6)] into which a first end [(21; 31)] of the channels [(20; 30)] of the first and of the second circuit respectively, emerge and, on the other hand, with said sealed chamber [(1)], an annular space [(7)] into which a second end [(22; 32)] of the channels [(20; 30)] of the first and of the second circuit respectively, emerge.

7. (Amended) The catalytic reactor as claimed in [any one of the preceding claims] claim 1, [characterized in that] wherein the means for admitting the reaction fluid comprise an inlet nozzle [(23)] passing through the sealed chamber [(1)] and connected to the lower end of the central well [(6)] of the bundle of plates [(10)] so as to place the first end [(21)] of the channels [(20)] forming the first circuit for the circulation of this reaction fluid in communication with said inlet nozzle [(23)] .

8. (Amended) The catalytic reactor as claimed in [any one of claims] claim 1 [to 6], [characterized in that] wherein the means for removing the reaction fluid comprise an outlet nozzle [(24)] emerging in said sealed chamber [(1)] at the annular space [(7)] and communicating with the second end [(22)] of the channels [(20)] forming the first circuit for the circulation of this reaction fluid.

9. (Amended) The catalytic reactor -as claimed in [any one of claims] claim 1 [to 6], [characterized in that] wherein the means for admitting the heat-transfer fluid comprise a main nozzle [(33)] passing through the sealed chamber [(1)] and ducts

[(34)] each connecting said main nozzle [(33)] and a vertical internal manifold [(35)] spanning the entire height of the central well [(6)] and covering a portion of the first ends [(21; 31)] of the channels [(20; 30)] that form the circuits.

10. (Amended) The catalytic reactor as claimed in [any one of claims] claim 1 [to 6], [characterized in that] the means for removing the heat-transfer fluid comprise several ducts [(37)] passing through the sealed chamber [(1)] and each connected to a vertical external manifold [(38)] spanning the entire height of the bundle of plates [(10)] at the annular space [(7)] and covering a portion of the second ends [(22; 32)] of the channels [(20; 30)] that form the second circuit.

11. (Amended) The catalytic reactor as claimed in claim 9 [or 10], [characterized in that] wherein the internal manifolds [(35)] and the external manifolds [(38)] are arranged in a star configuration.

12. (Amended) The catalytic reactor as claimed in [any one of the preceding claims] claim 1, [characterized in that] wherein the first ends [(21)] of the channels [(20)] forming the first circuit and situated between the internal manifolds [(35)] are open and the first ends [(21)] of said channels [(20)] situated below the internal manifolds [(35)] are blanked off, for example by a plate [(25)] .

13. (Amended) The catalytic reactor as claimed in any [one of the preceding claims] claim 1, [characterized in that] wherein the second ends [(22)] of the channels [(20)] forming the first circuit and situated between the external manifolds [(38)] are open and the second ends [(22)] of said channels [(20)] situated below the manifolds [(38)] are each blanked off, for example by a plate [(26)] .

14. (Amended) The catalytic reactor as claimed in [any one of claims] claim 1 [to 11], [characterized in that] wherein the first ends [(31)] of the channels [(30)] forming the second circuit and situated between the internal manifolds [(35)] are

blanked off, for example by a plate [(36)], and the first ends [(31)] of said channels [(30)] situated below the internal manifolds [(35)] are open.

15 (Amended) The catalytic reactor as claimed in [any one of claims] claim 1 [to 5 or 14], [characterized in that] wherein the second ends [(32)] of the channels [(30)] forming the second circuit and situated between the external manifolds [(38)] are each blanked off for example by a plate [(39)] and the second ends [(32)] of said channels [(30)] situated below the external manifolds [(30)] are open.

16. (Amended) The catalytic reactor as claimed in [any one of claims] claim 2 [to 15], [characterized in that] wherein the means for loading the catalyst [(5)] into the channels [(20)] of the first circuit are formed by an inlet duct [(40)] passing through the upper part of the sealed chamber [(1)] and connected to the open first ends [(21)] of the channels [(20)] forming the first circuit by a tubular sleeve [(41)] arranged in the central well [(6)] and spanning the entire height of said central well [(6)], said tubular sleeve [(41)] allowing the reaction fluid to pass from the inlet nozzle [(40)] as far as said open first ends [(21)].

18. (Amended) The catalytic reactor as claimed in [any one of claims] claim 2 [to 15], [characterized in that] wherein the means for unloading the catalyst [(5)] from the channels [(20)] of the first circuit are formed by an outlet duct [(45)] emerging at the lower part of the sealed chamber [(1)] and connected to the open second ends [(22)] of the channels [(20)] forming the first circuit by a tubular sleeve [(46)] arranged in the annular space [(7)] and spanning from the upper edge of the bundle of plates [(10)] as far as the lower part of said sealed chamber [(1)], said tubular sleeve [(46)] allowing the reaction fluid to pass from said open second ends [(22)] as far as the outlet nozzle [(45)].

Catalytic reactor with a bundle of plates

The subject of the present invention is a catalytic reactor with a bundle of plates for performing heat transfer between a reaction fluid reacting in contact with a catalyst and a heat-transfer fluid which provides or removes heat to or from the reaction fluid in order to improve the efficiency of the chemical reaction.

In many industries, such as petrochemical and chemical industries for example, use is made of treatment processes which employ reactors in which chemical reactions take place between a reaction fluid and a catalyst, which reactions are highly endothermic or exothermic and in which reactions heat is transferred between the reaction fluid and a heat-transfer fluid.

To do that, it is known practice to employ catalytic reactors formed of a sealed chamber inside which parallel tubes filled with catalyst are arranged.

The reaction fluid flows through these tubes inside which the chemical reaction takes place, and the heat-transfer fluid flows around the outside of ~~said~~ the tubes, between these and the interior wall of the chamber.

The main disadvantage of this type of catalytic reactor lies in its size, because, for large units, the number and length of the tube rapidly become very great and the size of the apparatus rapidly becomes excessive.

The specific problem is that the pressure drop in the catalyzer imposes a maximum length on the tubes and therefore dictates that there be a great many of ~~said~~ the tubes.

When this length is short and the volume of catalyst

needed for a commercial unit of reasonable size is high, the size and number of apparatuses needed make the use of tube-type catalytic reactors rather unattractive.

> insert ¶ re: USP 4,340,501

Plate-type catalytic reactors are also known and comprise a bundle of corrugated plates delimiting a first circuit for the circulation of the reaction fluid across a bed of catalyst and a second circuit for the circulation of heat-transfer fluid.

Plate-type catalytic reactors offer a better heat-exchange coefficient than tube-type catalytic reactors, but do exhibit certain drawbacks.

Specifically, the heat-exchange bundle is formed by a stack of corrugated and rectangular plates and generally therefore has a parallelepipedal overall shape.

The bundle of plates is placed in a sealed chamber which itself has a cylindrical overall shape.

Thus, the parallelepipedal overall shape of the bundle of plates proves to be an obstacle to optimum use of the internal space of the cylindrical chamber, which imposes an economic limit on this type of catalytic reactor given the high cost of the sealed chamber.

In addition, the two fluids which circulate through the bundle of plates may be at different pressures which means that the adjacent plates have a tendency to be pressed against each other by the difference in pressure between these fluids.

Now, the mechanical integrity of the corrugated plates is limited by the maximum thickness of metal of which the plates are made, because of the shaping of these

plates to produce the corrugations, which reduces the areas in which this type of catalytic reactor can be used.

Finally, an additional drawback of corrugated plates is the limited access they offer to the interior of the bundle of plates for inspecting these plates during shut-down of the catalytic reactor.

> Insert ¶ : "Finally, an additional...

It is an object of the invention to avoid these drawbacks by proposing a plate-type catalytic reactor which is more compact and is better able to withstand the difference in pressure between the fluids than the catalytic reactors hitherto used.

A subject of the invention is therefore a plate-type catalytic reactor for carrying out heat transfer between a reaction fluid reacting in contact with a catalyst and a heat-transfer fluid, of the type comprising a vertical and elongated sealed chamber, a bundle of plates arranged inside said sealed chamber and means for admitting and removing the reaction and heat-transfer fluids, characterized in that the chamber is of circular shape and in that the bundle of plates is formed of plates of frustoconical shape, superposed on one another and defining between one another, on the one hand, a series of channels containing the catalyst and forming a first circuit for the circulation of the reaction fluid and, on the other hand, a second series of channels forming a second circuit for the circulation of the heat-transfer fluid, the first circuit and the second circuit communicating with means for respectively admitting and removing the reaction fluid and the heat-transfer fluid.

6/PRTS

The subject of the present invention is a catalytic reactor with a bundle of plates for performing heat transfer between a reaction fluid reacting in contact with a catalyst and a heat-transfer fluid which provides or removes heat to or from the reaction fluid in order to improve the efficiency of the chemical reaction.

In many industries, such as petrochemical and chemical industries for example, use is made of treatment processes which employ reactors in which chemical reactions take place between a reaction fluid and a catalyst, which reactions are highly endothermic or exothermic and in which reactions heat is transferred between the reaction fluid and a heat-transfer fluid.

To do that, it is known practice to employ catalytic reactors formed of a sealed chamber inside which parallel tubes filled with catalyst are arranged.

The reaction fluid flows through these tubes inside which the chemical reaction takes place, and the heat-transfer fluid flows around the doutside of said tubes, between these and the interior wall of the chamber.

The main disadvantage of this type of catalytic reactor lies in its size, because, for large units, the number and length of the tube rapidly become very great and the size of the apparatus rapidly becomes excessive.

The specific problem is that the pressure drop in the catalyzer imposes a maximum length on the tubes and therefore dictates that there be a great many of said tubes.

When this length is short and the volume of catalyst

needed for a commercial unit of reasonable size is high, the size and number of apparatuses needed make the use of tube-type catalytic reactors rather unattractive.

Patent US-A-4 340 501 discloses a catalytic reactor formed of a cylindrical chamber containing plate elements spaced apart and which determine a zig-zag path for the circulation of fluid.

Plate-type catalytic reactors are also known and comprise a bundle of corrugated plates delimiting a first circuit for the circulation of the reaction fluid across a bed of catalyst and a second circuit for the circulation of heat-transfer fluid.

Plate-type catalytic reactors offer a better heat-exchange coefficient than tube-type catalytic reactors, but do exhibit certain drawbacks.

Specifically, the heat-exchange bundle is formed by a stack of corrugated and rectangular plates and generally therefore has a parallelepipedal overall shape.

The bundle of plates is placed in a sealed chamber which itself has a cylindrical overall shape.

Thus, the parallelepipedal overall shape of the bundle of plates proves to be an obstacle to optimum use of the internal space of the cylindrical chamber, which imposes an economic limit on this type of catalytic reactor given the high cost of the sealed chamber.

In addition, the two fluids which circulate through the bundle of plates may be at different pressures which means that the adjacent plates have a tendency to be

pressed against each other by the difference in pressure between these fluids.

Now, the mechanical integrity of the corrugated plates is limited by the maximum thickness of metal of which the plates are made, because of the shaping of these plates to produce the corrugations, which reduces the areas in which this type of catalytic reactor can be used.

Finally, an additional drawback of corrugated plates is the limited access they offer to the interior of the bundle of plates for inspecting these plates during shut-down of the catalytic reactor.

This is the case, in particular, of the catalytic reactor described in Patent EP-A-766 999 which comprises several bundles of plates arranged in a star configuration in a sealed cylindrical chamber.

It is an object of the invention to avoid these drawbacks by proposing a plate-type catalytic reactor which is more compact and is better able to withstand

According to other features of the invention:

- the catalytic reactor comprises means for loading and unloading the catalyst into and from the series of channels forming the first circuit for the circulation of the reaction fluid,

- the plates of frustoconical shape are smooth or have corrugations,

- the channels of the first circuit and of the second circuit alternate with one another,

- the plates of the bundle of plates form on the one hand, along the axis of the sealed chamber, a central well into which a first end of the channels of the first and of the second circuit respectively, emerge and, on the other hand, with said sealed chamber, an annular space into which a second end of the channels of the first and of the second circuit respectively, emerge,

- the means for admitting the reaction fluid comprise an inlet nozzle passing through the sealed chamber and connected to the lower end of the central well of the bundle of plates so as to place the first end of the channels forming the first circuit for the circulation of this reaction fluid in communication with said inlet nozzle,

- the means for removing the reaction fluid comprise an outlet nozzle emerging in said sealed chamber at the annular space and communicating with the second end of the channels forming the first circuit for the circulation of this reaction fluid,

- the means for admitting the heat-transfer fluid comprise a main nozzle passing through the sealed chamber and ducts each connecting said main nozzle and a vertical internal manifold spanning the entire height of the central well and covering a portion of the first ends of the channels that form the circuits,

- the means for removing the heat-transfer fluid comprise several ducts passing through the sealed chamber and each connected to a vertical external

manifold spanning the entire height of the bundle of plates at the annular space and covering a portion of the second ends of the channels that form the circuits,

- the internal manifolds and the external manifolds are arranged in a star configuration,

- the first ends of the channels forming the first circuit and situated between the internal manifolds are open and the first ends of said channels situated below the internal manifolds are blanked off, for example by a plate,

- the second ends of the channels forming the first circuit and situated between the external manifolds are open and the second ends of said channels are each blanked off, for example by a plate,

- the first ends of the channels forming the second circuit and situated between the internal manifolds are each blanked off, for example by a plate, and the first ends of said channels situated below the internal manifolds are open,

- the second ends of the channels form the second circuit and situated between the external manifolds are each blanked off for example by a plate and the second ends of said channels situated below the external manifolds are open,

- the means for loading the catalyst into the channels of the first circuit are formed by an inlet duct passing through the upper part of the sealed chamber and connected to the open first ends of the channels forming the first circuit by a tubular sleeve arranged in the central well and spanning the entire height of said central well, said tubular sleeve allowing the reaction fluid to pass from the inlet nozzle as far as said open first ends,

- the means for unloading the catalyst from the channels of the first circuit are formed by an outlet duct emerging at the lower part of the sealed chamber and connected to the open second ends of the channels forming the first circuit by a tubular sleeve arranged

in the annular space and spanning from the upper edge of the bundle of plates as far as the lower part of said sealed chamber, said tubular sleeve allowing the reaction fluid to pass from said open second ends as far as the outlet nozzle.

The invention will be better understood from reading the description which will follow, given by way of example and made with reference to the appended drawings, in which:

- fig. 1 is a schematic perspective view with partial cutaway of a catalytic reactor according to the invention,
- fig. 2 is a view in cross section of the catalytic reactor according to the invention,
- fig. 3 to 6 are part views on a larger scale of details 3 to 6 of fig. 2, respectively,
- fig. 7 is a partial development of the interior face of the bundle of plates of the catalytic reactor according to the invention,
- fig. 8 is a partial development of the exterior face of the bundle of plates of the catalytic reactor according to the invention.

Figures 1 and 2 schematically depict a plate-type catalytic reactor denoted overall by the reference 1 and intended more especially for highly endothermic and exothermic chemical reactions in which heat is transferred between a reaction fluid A which reacts in contact with a catalyst and a heat-transfer fluid B which provides or removes heat to or from the reaction fluid A.

The transfer of heat between the two fluids A and B makes it possible to improve the efficiency of the chemical reaction.

The sealed chamber 1 is formed by a cylindrical central

part 2 arranged vertically and equipped, at its upper end, with an upper domed end 3 and, at its lower end, with a lower domed end 4.

Arranged inside the chamber 1 is a bundle of plates denoted by the general reference 10, spanning part of the length of this sealed chamber 1 and oriented along the vertical axis of said sealed chamber 1.

As depicted in the figures, the bundle of plates 10 is formed of plates 11 each of frustoconical shape, superposed on one another so as to define between them gaps, the slope of which runs downward with respect to the axis of the sealed chamber 1.

The gaps defined between the plates 11 determine, on the one hand, a series of channels 20 forming a first circuit for the circulation of the reactor fluid A and, on the other hand, a series of channels 30 forming a second circuit for the circulation of heat-transfer fluid B.

The channels 20 of the first circuit and the channels 30 of the second circuit alternate with one another and, in the embodiment depicted in the figures, the channels 20 are arranged between the channels 30.

The channels 20 of the first circuit for the circulation of the reaction fluid A are filled with a catalyst 5 formed with small-sized grains of any shape.

The superposed plates 11 of the bundle of plates 10 determine, on the one hand, along the axis of the sealed chamber 1, a central well 6 and, on the other hand, with said sealed chamber 1, a peripheral annular space 7.

A first end 21 of the channels 20 of the first circuit

for the circulation of the reaction fluid A and a first end 31 of the channels 30 of the second circuit for the circulation of the heat-transfer fluid B emerge in the central well 6.

A second end 22 of the channels 20 of the first circuit for the circulation of the reaction fluid A and a second end 32 of the channels 30 of the second circuit for the circulation of the heat-transfer fluid B emerge in the annular space 7.

The catalytic reactor also comprises means for admitting and removing the reaction fluid A, means for admitting and removing the heat-transfer fluid B, and means for loading and unloading the catalyst 5 into and from the series of channels 20 that form the first circuit for the circulation of said reaction fluid A.

The means for admitting reaction fluid A comprise an inlet nozzle 23 passing through the domed lower end 4 of the sealed chamber 1 and connected to the lower end of the central well 6 of the bundle of plates 10 so as to place the first end 21 of the channels 20 forming the first circuit for the circulation of the reaction fluid A in communication with said inlet nozzle 23.

The means for removing this reaction fluid A after it has passed through the channels 20 containing the catalyst 5 comprise an outlet nozzle 24 emerging more or less in the central part of the sealed chamber 1 at the peripheral annular space 7 and communicating with the second end 22 of the channels 20, said end emerging in this peripheral annular space 7.

The means for admitting the heat-transfer fluid B comprise a main nozzle 33 passing through the domed upper end 3 of the sealed chamber 1 and ducts 34 each connecting said main nozzle 33 to a vertical internal

manifold 35.

Each internal manifold 35 spans the entire height of the central well 6 and covers a portion of the first end 31 of the channels 30 that form the second circuit for the circulation of said heat-transfer fluid B.

In the embodiment depicted in the figures, there are six of these internal manifolds 35, each connected by a duct 34 to the main nozzle 33.

These internal manifolds 35 are arranged in a star configuration on the internal face of the bundle of plates 10.

As depicted in fig. 7, which is a partial development of the interior wall of the bundle of plates 10, that is to say of the internal face at the central well 6, the reaction fluid A and heat-transfer fluid B are routed respectively through the channels 20 and through the channels 30.

For this purpose, the first ends 21 of the series of channels 20 forming the first circuit for the circulation of the reaction fluid A and situated between the internal manifolds 35 are open and the first ends 21 of said channels 20 situated below the internal manifolds 35 are each blanked off for example by a plate 25.

Furthermore, the first ends 31 of the series of channels 30 forming the second circuit for the circulation of the heat-transfer fluid B and situated between the internal manifolds are each blanked off for example by a plate 36 while the first ends 31 of these channels 30 situated above the internal manifolds 35 are open.

The means for removing the heat-transfer fluid B comprise several independent ducts 37 which pass through the lower domed end 4 of the sealed chamber 1 and which are each connected to a vertical external manifold 38 arranged in the annular space 7.

Each external manifold 38 spans the entire height of the external wall of the bundle of plates 10 at said annular space 7 and covers a portion of the second end 32 of the series of channels 30 forming the second circuit for the circulation of the heat-transfer fluid B.

In the embodiment depicted in the figures, there are also six of these external manifolds 38, each connected to a duct 37 and which are distributed in a star configuration on said external face of the bundle of plates 10.

As depicted more specifically in fig. 8 which is a partial development of the exterior face of the bundle of plates 10, that is to say in the region of the annular space 7, the second ends 22 of the channels 20 forming the first circuit for the circulation of the reaction fluid A and situated between the external manifolds 38 are open while the second ends 22 of said channels 20 situated below the external manifolds 38 are each blanked off for example by a plate 26.

Furthermore, the second ends 32 of the channels 30 forming the second circuit for the circulation of the heat-transfer fluid B and situated between the external manifolds 38 are each blanked off for example by a plate 39 and the second ends 32 of said channels 30 situated below the external manifolds 38 are open.

As depicted in particular in figs 2 and 5, the means for loading the catalyst 5 through the first ends 21 of

the channels 20 into the first circuit for circulation of the reaction fluid A are formed by an inlet duct 40 passing through the upper domed end 3 of the sealed chamber 1 and connected to the open first ends 21 of the channels 20 forming said first circuit by a tubular sleeve 41 arranged inside the central well 6.

The inlet duct 40 opens into a manifold 42 fixed to the upper end of the central well 6.

A cone 43 is arranged inside the manifold 42 on the upper end of the central well 6 so as to route the catalyst 5 discharged by the inlet duct 40 in the tubular sleeve 41 toward the inlets 21 of the series of channels 20.

The bottom of the central well 6 is blanked off by a horizontal plate 44 formed of a grating.

In an alternative form, the lower part of the internal manifolds 35 is blanked off by an annular grating, leaving the central cross section of the well 6 unobstructed.

The tubular sleeve 41 spans the entire height of the central well 6 and allows the reaction fluid A to pass from the inlet nozzle 23 as far as the open first ends 21 of the series of channels.

As a preference, this tubular sleeve 41 is formed of a grating.

The means for unloading the catalyst 5 from the channels 20 of the first circuit for the circulation of the reaction fluid A when this catalyst 5 is spent, are formed of an outlet duct 45 passing through the domed lower end 4 of the sealed chamber 1 and which is connected to the open second ends 22 of the channels 20

forming the first circuit by a tubular sleeve 46 (figs 2 and 6) arranged in the peripheral annular space 7.

This tubular sleeve 46 spans from the upper edge of the outlets 32 of the channels 30 of the bundle of plates 10 as far as the lower part of the chamber 1 and allows the reaction fluid A to pass from the open second ends 22 as far as the outlet nozzle 45.

As a preference, the tubular sleeve 46 is formed of a grating.

The plates 25, 36 and 26, 39 are welded to the edges 11 of the bundle of plates 10 and the manifolds 35 and 38 are also welded to the plates 11 and may also serve to hold these plates together.

The reaction fluid A arriving via the inlet nozzle 23 passes through the grating 44 and spreads out in the central well 6.

This reaction fluid A enters the series of channels 20 of the first circuit via the open first ends 21 of these channels 20.

As it passes into this series of channels 20 containing the catalyst 5, a highly endothermic or exothermic chemical reaction takes place, depending on the type of fluid used and the desired application.

Once it has passed through the series of channels 20, the reaction fluid A passes through the tubular sleeve 46, spreads out inside the sealed chamber 1, and is removed via the outlet nozzle 24.

At the same time as the reaction fluid A is circulating, the heat-transfer fluid B arrives via the main nozzle 33 and via the ducts 34 in the internal

manifolds 35.

The heat-transfer fluid B enters the series of channels 30 of the second circuit by passing through the open ends 31 of this second circuit and diffuses uniformly throughout the channels 30.

Depending on the application and on the type of heat-transfer fluid B used, as it passes through the channels 30 of the second circuit, this heat-transfer fluid carries out heat transfer by providing or removing heat to or from the reaction fluid 1, making it possible to improve the efficiency of the chemical reaction.

Once it has passed through the channels 30, the heat-transfer fluid B leaves via the open second ends 32 of the channels 30 and is then collected by the external manifolds 38 and removed by the outlet ducts 37.

The frustoconically shaped plates 11 of the bundle of plates 10 may be smooth or may have corrugations.

When the catalyst 5 is being renewed, the outlet duct 45 is opened and the catalyst 5 flows out through this outlet duct 45 and, because of the slope of the channels 20, this catalyst 5 is removed from said channels 20.

To fill the channels 20 with fresh catalyst 5, the outlet duct 45 is closed and the fresh catalyst 5 is poured in through the inlet duct 40 into the tubular sleeve 41 and spreads out in the channels 20 of the first circuit for the circulation of the reaction fluid A.

Each time the catalyst has to be replaced, this operation is repeated.

By comparison with a tubular catalytic reactor, the configuration of the reactor according to the invention offers the advantage of a true co-current heat exchange configuration over most of the heat-exchange length.

By comparison with a catalytic reactor comprising a cylindrical sealed wrapper and a plate bundle of parallelepipedal overall shape, the configuration of the catalytic reactor according to the invention makes it possible to be able to circulate fluids with higher pressure differences.

The catalytic reactor according to the invention has the advantage, as a result of its design, of being compact by virtue of the shape of the bundle of plates which advantageously fills the space of the sealed wrapper thus making it possible to reduce the cost of this sealed wrapper.

In addition, the catalytic reactor according to the invention has better ability to withstand the difference in pressure between the fluids, also by virtue of the shape of the plates of which the bundle of plates is made, making it possible to balance the pressure difference by developing a hoop stress which can easily be kept below a given value that is permissible for the material of which the plates are made, by adjusting the thickness of these plates.

Finally, the catalytic reactor according to the invention allows easy filling with catalyst because of the slope of the channels and easier access to the interior of the bundle of plates for cleaning or inspection for maintenance purposes.

CLAIMS

1. A plate-type catalytic reactor for carrying out heat transfer between a reaction fluid reacting in contact with a catalyst and a heat-transfer fluid, of the type comprising a vertical and elongated sealed chamber (1), a bundle of plates (10) arranged inside said sealed chamber (1) and means for admitting and removing the reaction and heat-transfer fluids, characterized in that the sealed chamber (1) is of circular shape and in that the bundle of plates (10) is formed of plates (11) of frustoconical shape, superposed on one another and defining between one another, on the one hand, a series of channels (20) containing the catalyst (5) and forming a first circuit for the circulation of the reaction fluid and, on the other hand, a second series of channels (30) forming a second circuit for the circulation of the heat-transfer fluid, the first circuit and the second circuit communicating with means for respectively admitting and removing the reaction fluid and the heat-transfer fluid.

2. The catalytic reactor as claimed in claim 1, characterized in that it comprises means for loading and unloading the catalyst (5) into and from the series of channels (20) forming the first circuit for the circulation of the reaction fluid.

3. The catalytic reactor as claimed in claim 1, characterized in that the plates (11) of frustoconical shape are smooth.

4. The catalytic reactor as claimed in claim 1, characterized in that the plates (11) of frustoconical shape have corrugations.

5. The catalytic reactor as claimed in claim 1 or 2, characterized in that the channels (20; 30) of the first circuit and of the second circuit alternate with one another.

6. The catalytic reactor as claimed in any one of the preceding claims, characterized in that the plates (11) of the bundle of plates (10) form on the one hand, along the axis of the sealed chamber (1), a central well (6) into which a first end (21; 31) of the channels (20; 30) of the first and of the second circuit respectively, emerge and, on the other hand, with said sealed chamber (1), an annular space (7) into which a second end (22; 32) of the channels (20; 30) of the first and of the second circuit respectively, emerge.

7. The catalytic reactor as claimed in any one of the preceding claims, characterized in that the means for admitting the reaction fluid comprise an inlet nozzle (23) passing through the sealed chamber (1) and connected to the lower end of the central well (6) of the bundle of plates (10) so as to place the first end (21) of the channels (20) forming the first circuit for the circulation of this reaction fluid in communication with said inlet nozzle (23).

8. The catalytic reactor as claimed in any one of claims 1 to 6, characterized in that the means for removing the reaction fluid comprise an outlet nozzle (24) emerging in said sealed chamber (1) at the annular space (7) and communicating with the second end (22) of the channels (20) forming the first circuit for the circulation of this reaction fluid.

9. The catalytic reactor as claimed in any one of

claims 1 to 6, characterized in that the means for admitting the heat-transfer fluid comprise a main nozzle (33) passing through the sealed chamber (1) and ducts (34) each connecting said main nozzle (33) and a vertical internal manifold (35) spanning the entire height of the central well (6) and covering a portion of the first ends (21; 31) of the channels (20; 30) that form the circuits.

10. The catalytic reactor as claimed in any one of claims 1 to 6, characterized in that the means for removing the heat-transfer fluid comprise several ducts (37) passing through the sealed chamber (1) and each connected to a vertical external manifold (38) spanning the entire height of the bundle of plates (10) at the annular space (7) and covering a portion of the second ends (22; 32) of the channels (20; 30) that form the second circuit.

11. The catalytic reactor as claimed in claim 9 or 10, characterized in that the internal manifolds (35) and the external manifolds (38) are arranged in a star configuration.

12. The catalytic reactor as claimed in any one of the preceding claims, characterized in that the first ends (21) of the channels (20) forming the first circuit and situated between the internal manifolds (35) are open and the first ends (21) of said channels (20) situated below the internal manifolds (35) are blanked off, for example by a plate (25).

13. The catalytic reactor as claimed in any one of the preceding claims, characterized in that the second ends (22) of the channels (20) forming the first circuit and situated between the external manifolds (38) are open and the second ends (22)

of said channels (20) situated below the manifolds (38) are each blanked off, for example by a plate (26).

14. The catalytic reactor as claimed in any one of claims 1 to 11, characterized in that the first ends (31) of the channels (30) forming the second circuit and situated between the internal manifolds (35) are blanked off, for example by a plate (36), and the first ends (31) of said channels (30) situated below the internal manifolds (35) are open.

15. The catalytic reactor as claimed in any one of claims 1 to 5 or 14, characterized in that the second ends (32) of the channels (30) forming the second circuit and situated between the external manifolds (38) are each blanked off for example by a plate (39) and the second ends (32) of said channels (30) situated below the external manifolds (30) are open.

16. The catalytic reactor as claimed in any one of claims 2 to 15, characterized in that the means for loading the catalyst (5) into the channels (20) of the first circuit are formed by an inlet duct (40) passing through the upper part of the sealed chamber (1) and connected to the open first ends (21) of the channels (20) forming the first circuit by a tubular sleeve (41) arranged in the central well (6) and spanning the entire height of said central well (6), said tubular sleeve (41) allowing the reaction fluid to pass from the inlet nozzle (40) as far as said open first ends (21).

17. The catalytic reactor as claimed in claim 16, characterized in that the tubular sleeve (41) is formed of a grating.

18. The catalytic reactor as claimed in any one of claims 2 to 15, characterized in that the means for unloading the catalyst (5) from the channels (20) of the first circuit are formed by an outlet duct (45) emerging at the lower part of the sealed chamber (1) and connected to the open second ends (22) of the channels (20) forming the first circuit by a tubular sleeve (46) arranged in the annular space (7) and spanning from the upper edge of the bundle of plates (10) as far as the lower part of said sealed chamber (1), said tubular sleeve (46) allowing the reaction fluid to pass from said open second ends (22) as far as the outlet nozzle (45).

19. The catalytic reactor as claimed in claim 18, characterized in that the tubular sleeve (46) is formed of a grating.

20. The catalytic reactor as claimed in claim 6, characterized in that the bottom of the central well (6) is blanked off by a horizontal plate (44) formed of a grating.

21. The catalytic reactor as claimed in claim 9, characterized in that the lower part of the internal manifolds (35) is blanked off by an annular grating, leaving the central cross section of the well (6) unobstructed.

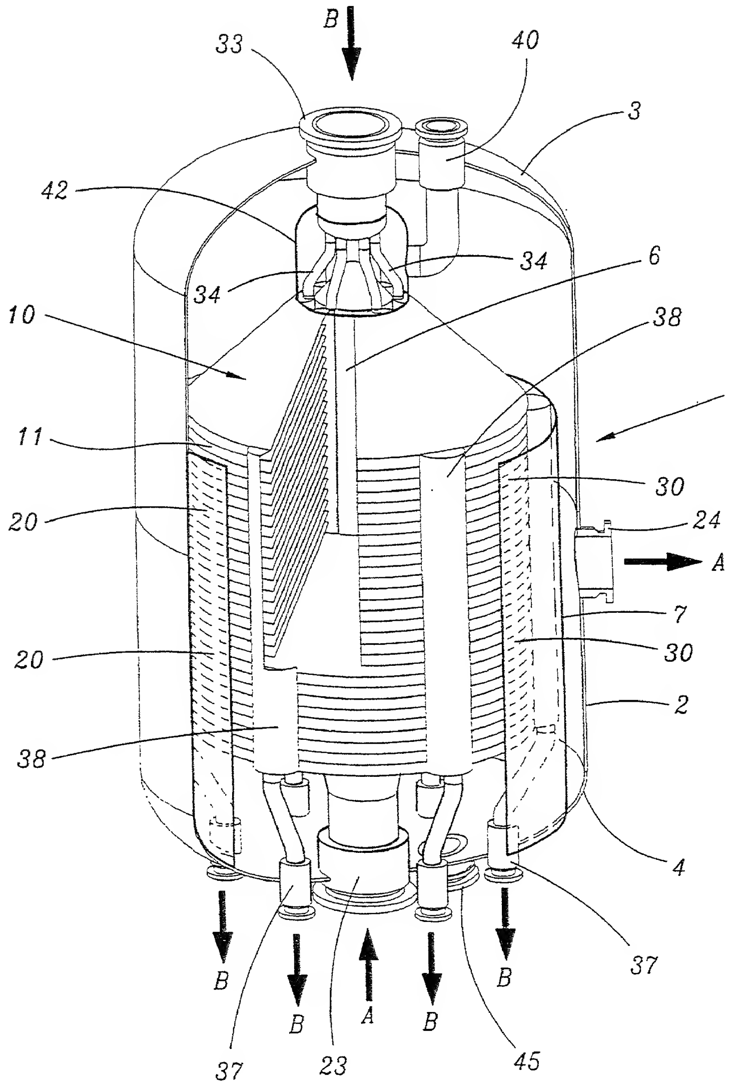
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FIG.1

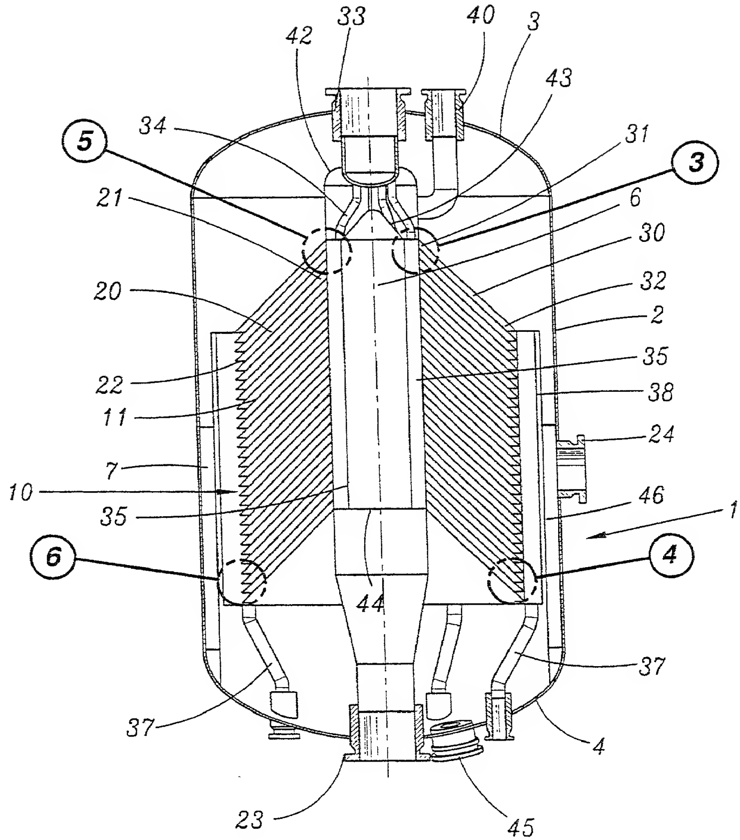
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FIG.2

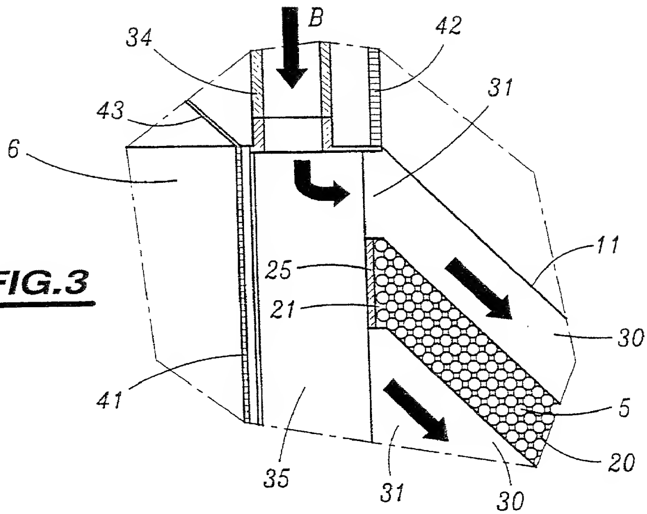
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FIG.3

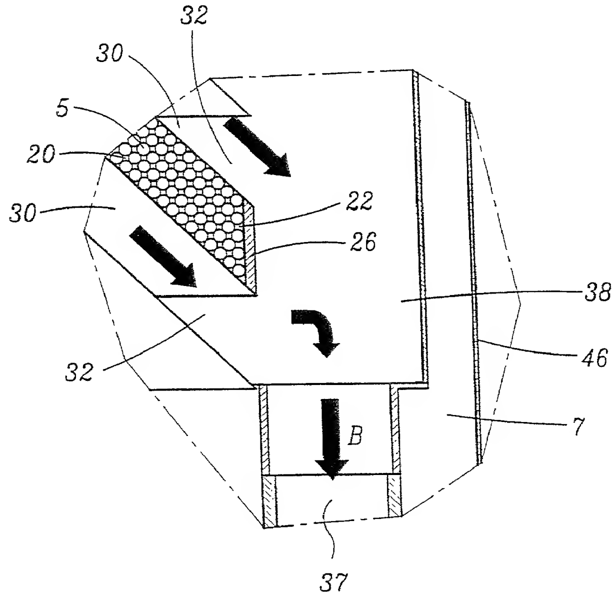
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FIG.4

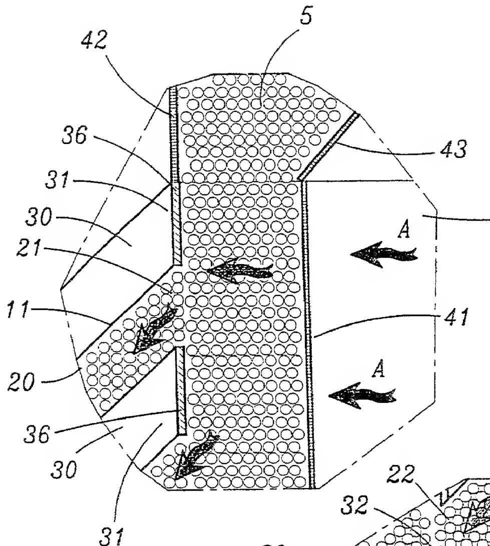
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FIG.5

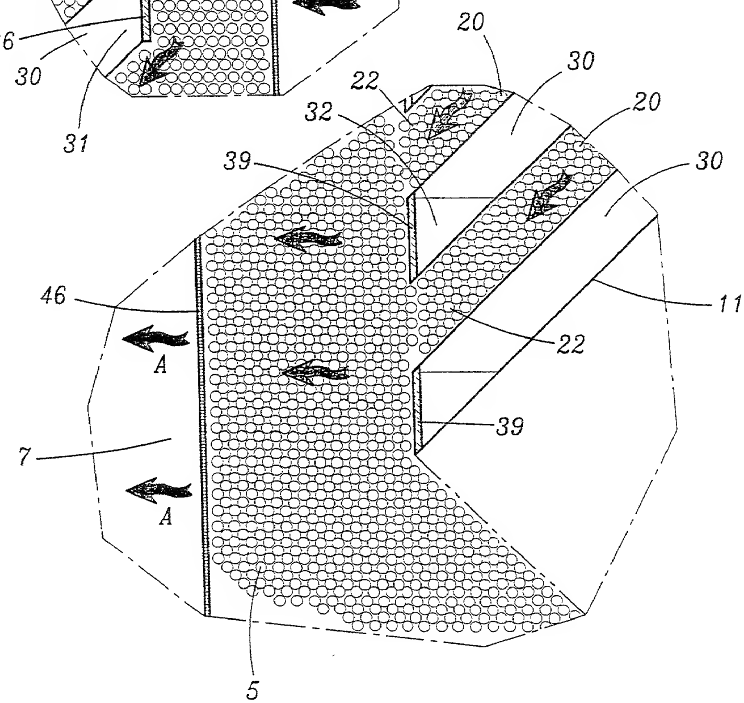
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FIG.6

5/6

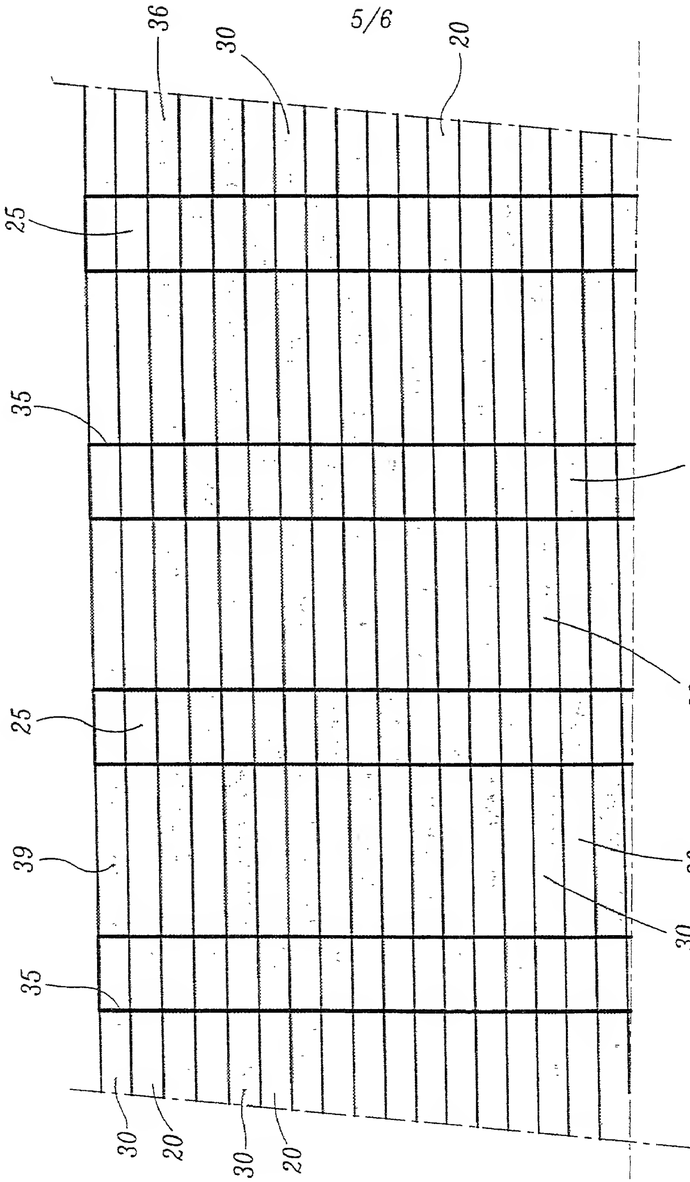

FIG.7

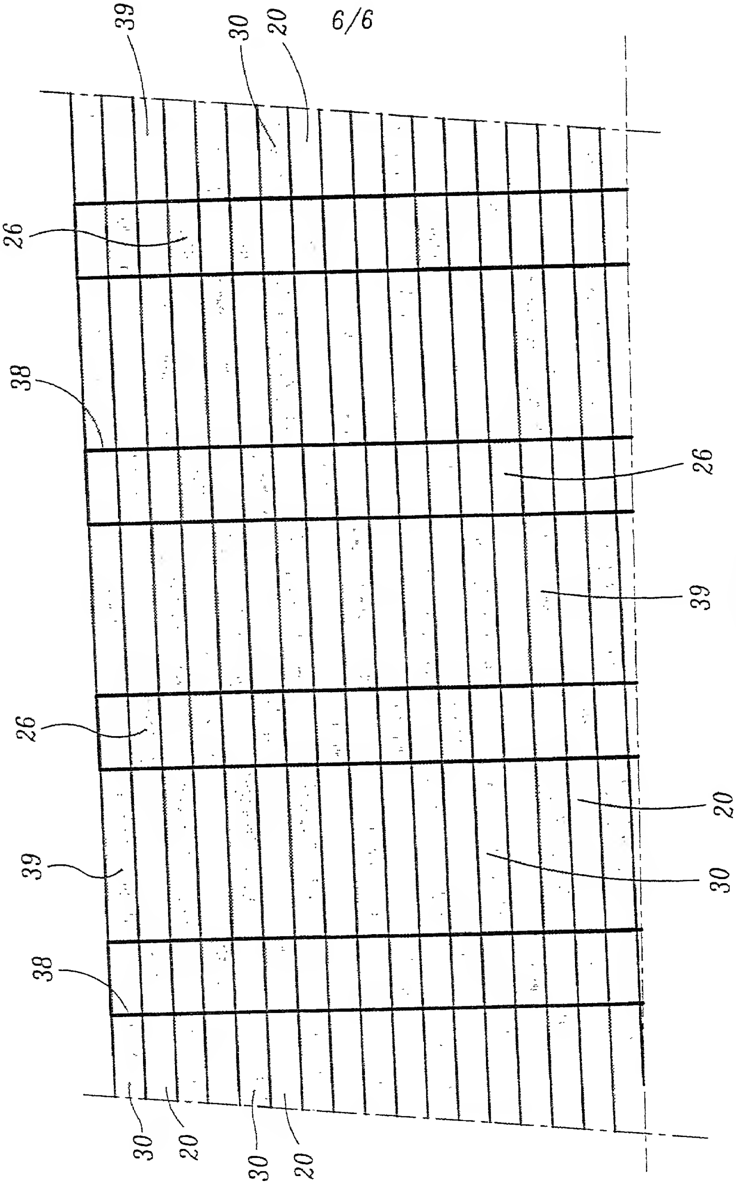

FIG.8

DECLARATION FOR PATENT APPLICATION

As a below-named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.
I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Catalytic reactor with a bundle of plates

the specification of which: (check one)

[ ] is attached hereto. [X] was filed on 15/02/2000, as United States Patent Application Serial No. or PCT International Application Number PCT/FR00/00373, and was amended on ______ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with 37 CFR § 1.56(a)

Prior Foreign Application(s): I hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate listed below, or § 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

(Application No.)	(Country)	(Day/Month/Year Filed)	Priority Claimed
9902918	FRANCE	09/03/99	[X] Yes [ ] No
			[ ] Yes [ ] No
			[ ] Yes [ ] No

I hereby claim the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below·

Application No.	Filing Date

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by 35 U.S.C. § 112, first paragraph, I acknowledge the duty to disclose material information as defined in 37 CFR § 1 56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(U.S. Application Serial No.)	(U.S. Filing Date)	(Status--patented, pending, abandoned)

I hereby appoint the following registered practitioners Rudolf E. Hutz, Reg. No. 22,397; John D Fairchild, Reg No 19,756, Harold Pezzner, Reg. No. 22,112; Richard M Beck, Reg No. 22,580, Paul E Crawford, Reg. No 24,397; Burton A Amernick, Reg No 24,852, Morris Liss, Reg. No. ~~24,510~~, George R. Pettit, Reg. No. 27,369; Patricia Smink Rogowski, Reg. No. 33,791, Robert G. McMorrow, Jr., Reg. No. 30,962, Ashley I. Pezzner, Reg ~~No. 35,646~~, William E. McShane, Reg. No. 32,707, Mary W. Bourke, Reg. No. 30,982; Gerard M. O'Rourke, Reg. No. 39,794; James M Olsen, Reg No. 40,408, Francis DiGiovanni, Reg No. 37,310; Eric J. Evain, Reg No. 42,517, William E. Curry, Reg. No 43,572; David W Ward, Reg. No. 45,198; Daniel C Mulveny, Reg. No. 45,897, John A. Evans, (Agent) 44,100; and Elliot C. Mendelson (Agent), Reg No. 42,878, with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

Send Correspondence and Direct Telephone Calls to:
Morris Liss
(202) 331-7111

Morris Liss
Connolly Bove Lodge & Hutz LLP
P.O. Box 19088
Washington, D.C. 20036-3425 U.S.A.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon

Full name of sole or first inventor William LEVY
Inventor's Signature ______ Date 16/10/01
Residence Address 6, rue de Trévise - 75009 PARIS - FRANCE
Citizenship French
Post Office Address The same as above

[ ] *See next page for additional inventors*

DECLARATION FOR PATENT APPLICATION

Page Two

Full name of second joint inventor (if any): 2-D Pierre JOLY
Inventor's Signature Date 16/10/01
Residence Address 34, avenue St Laurent - 91400 ORSAY - FRANCE FR
Citizenship French
Post Office Address The same as above

Full name of third joint inventor (if any): 3-D Dominique SABIN
Inventor's Signature Date 16/10/01
Residence Address 10, voie Grisée - 78580 HERBEVILLE - FRANCE FR
Citizenship French
Post Office Address The same as above

Full name of fourth joint inventor (if any): 4-D Régis HUGUET
Inventor's Signature Date 16/10/01
Residence Address 6, Clos de Lavelle - 71380 EPERVANS - FRANCE FR
Citizenship French
Post Office Address The same as above

Full name of fifth joint inventor (if any): 5-D Gilbert GRAILLE
Inventor's Signature Date 16/10/01
Residence Address 4, rue de Normandie - 71880 CHATENOY LE ROYAL - FRANCE FR
Citizenship French
Post Office Address The same as above

Full name of sixth joint inventor (if any): 6-D Pierre BUSSONNET
Inventor's Signature Date 16/10/01
Residence Address 52a, rue de Rochefort - 71100 CHALON SUR SAONE - FRANCE FR
Citizenship French
Post Office Address The same as above

Full name of seventh joint inventor (if any): 7-D Eric GILBERT-DESVALLONS
Inventor's Signature Date 16/10/01
Residence Address 4, rue Fontaine Melon - 71380 ST MARCEL - FRANCE FR
Citizenship French
Post Office Address The same as above

Full name of eighth joint inventor (if any):
Inventor's Signature Date
Residence Address
Citizenship
Post Office Address

Full name of ninth joint inventor (if any):
Inventor's Signature Date
Residence Address
Citizenship
Post Office Address